ABI Formulation Phase Contract

Statement of Work

July 18, 2000

1. Introduction

The Advanced Baseline Imager (ABI) will be an infra-red (IR) and visible (VIS) imaging instrument that is planned for infusion into the GOES program series of geosynchronous satellites to replace the current GOES imager. The ABI will meet, as a minimum, the National Aeronautics and Space Administration (NASA) requirements as defined in Section J of this RFP, ABI Performance and Operation Requirements Document (often referred to within this document as the "ABI requirements" or the “PORD”), and the ABI Interface Requirements Document (IRD). For this procurement, the ABI Performance and Operation Requirements Document supersedes all other requirements documents.

This statement of work (SOW) specifies the vendor requirements for performing definition-phase studies and design development as part of ABI formulation activities.

The work described in this SOW is not all of equal importance or weight. The term "shall" designates the most important weighting level; that is, mandatory. Any deviations from these contractually imposed mandatory items require the approval of the contracting officer. A lesser term, "should", designates work requested or recommended by the government, but is not mandatory. Completion of non-mandatory work is left to the discretion of the study contractor.

2. Tasks

The contractor shall analyze the ABI requirements, perform trade studies to justify design decisions, develop a preliminary design for the Advanced Baseline Imager, and perform all other tasks as specified below.

2.1 Trade Studies and General Analyses

2.1.1 The contractor shall perform the following trade studies and report on the results at the Midterm Review.

1) A potential additional channel study. This study shall evaluate the ABI design, risk, and implementation cost and schedule impacts (both non-recurring and recurring) of implementing at least 8, but not more than 12 spectral channels, as specified in Section 3.2.2 of the ABI Performance and Operation Requirements. As part of this study, the study contractor should identify and discuss the point(s) in the trade space at which passive cooling becomes infeasible or undesirable.

   There shall be no other channel options that call for more than 12 channels.

2) A "zones of reduced data quality" study. This study shall evaluate minimization of reduced data quality zones (see ABI Performance and Operation Requirements, Section 3.1.4.3), evaluating the ABI design, performance, risk, and implementation cost and schedule impacts (both non-recurring and recurring) of various techniques. As part of this study, the study contractor shall propose the reduced data quality zones required by the ABI for degraded performance and the specification the instrument would meet in this mode. If there are significant differences between the spectral bands, the study contractor shall provide the impact on each channel.

3) Ground sample distance study. This study shall evaluate the impact of visible and infrared channel ground sample distances other than the baseline 0.5 and 1 kilometer, respectively, on interpolation and resampling algorithm performance (see ABI Performance and Operation Requirements, Section 3.2.3). The contractor shall show, through simulations and/or analysis, how radiometric accuracy is affected when undersampled infrared data (i.e. greater than 1 km) is interpolated and resampled to the fixed grid. The contractor shall perform similar analyses and/or simulations to show how image quality is affected when visible data gathered at various sample distances is interpolated and resampled to the fixed grid. The study shall consider impacts to system-level parameters such as data rates. The study shall consider the impact of sample distance on the ability to accurately normalize spatial resolution across channels when developing multispectral products. The study shall evaluate the performance, design, risk, and implementation cost and schedule impacts (both non-recurring and recurring) of implementing various visible and infrared ground sample distances. Standard earth scenes will be made available by the government for this study after contract award.

4) A rapid local area image update study. This study shall evaluate the ABI design, risk, and implementation cost and schedule impacts (both non-recurring and recurring) of achieving the goal requirement of implementing rapid local area image updates concurrently with Full Earth and CONUS coverage (as defined in the ABI Performance and Operation Requirements, Section 3.2.1.1, Mode 3).

5) A standard interfaces study. The contractor shall evaluate the design, performance, risk, cost, and schedule impacts (both non-recurring and recurring) of implementing (or not implementing) standard electrical and data interfaces. The contractor shall define an open architecture (i.e., non-proprietary) that supports modularity and pre-planned improvements (PPI). The contractor shall review and comment on the following documents: the common section of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Sensor Requirements Document (SRD); the draft US Position Paper for the CCSDS standard for Spacecraft On-board Interfaces (SOIF); the draft CCSDS Position Paper on the SOIF Reference Model; and the JPL X2000 interface standard. In addition, the contractor shall evaluate standardizing the following: 1) data busses (IEEE-1394, MIL-STD-1553B, and I^2C), 2) +28VDC power, 3) UART/RS-422 and ethernet test ports, 4) electronic

back-planes (cPCI), 5) an electronics board size (6Ux160), 6) the CCSDS/SOIF proposed reference model, and 7) System Firmware (to support plug-and-play). The contractor shall also propose an instrument/spacecraft command and power architecture. Finally, the contractor shall consider and develop as appropriate a commercialization plan that makes ABI components, electronic cards, flight systems, and test systems available in a standard catalog.

6) Additional trade studies as proposed by the study contractor.

2.1.2 The contractor shall identify the instrument design, cost, and risk drivers and recommend at the Midterm Review requirements modifications that would make the ABI more cost effective to develop and produce. In so doing, the contractor shall evaluate all goal requirements (i.e., all "should" requirements) in the PORD in terms of cost effectiveness and risk, and recommend at the Midterm review requirements modifications to establish more firm performance requirements for these parameters. Quantify potential cost savings of requirements changes by an absolute or relative cost impact measure. Alternative approaches to the requirements should be presented prior to the Midterm Review for consideration by the government as ABI Requirements modifications. The contractor is encouraged to present draft information on such possible changes at the progress review preceding the Midterm Review or sooner to allow the government time to analyze the proposed requirement modifications and provide feedback at the Midterm Review.

2.2 ABI Preliminary Design Development and Related Analyses

2.2.1 The contractor shall develop a preliminary ABI design and perform associated engineering analyses to justify design parameters, tolerances, and design/performance margins such that, as a minimum, the design elements listed in Section 3.5 are addressed. The ABI shall be decomposed into subsystem elements and component parts. The design should allow for modular manufacture, integration, assembly, and test. The modular design should also allow for technology and performance upgrades as GOES project requirements evolve, especially in the areas of number of spectral channels, coverage rate, and radiometric performance.

2.2.2 The contractor shall define the calibration approach for the ABI (both prelaunch and post launch). The contractor shall quantify the radiometric errors produced by white noise, 1/f noise, thermal drifts of the detector and the optical elements, and systematic variations in the ABI optical throughput over its field of regard. The calibration analysis shall address correlated radiometric errors, such as shading and striping, as well as the errors in a single pixel, and shall quantify the mitigation of these errors as a function of the frequency of onboard calibration measurements.

2.2.3 The contractor shall define (function, host processor), estimate the size of (lines of code, implementation language), and develop a preliminary design and specification for the software that will be developed for the ABI in the Implementation Phase including the flight software, integration and test software, and simulation software.

2.2.4 The contractor shall perform detailed analysis of the performance of all detectors as a function of detector temperature and temperature stability. The contractor shall corroborate these performance predictions and the proposed designs of focal plane cooling and thermal control systems through comparison to data from similar detector and cooler hardware that has been validated through thermal testing. This comparison shall include, but not be limited to, electric power dissipation on the focal plane, thermal conductivity of electrical connections and mechanical supports, and parasitic thermal conduction and radiation in the cooling system proposed by the contractor. If the contractor proposes active mechanical coolers, this analysis shall include an assessment of the effects of their vibration on system performance and their reliability over the mission lifetime (lifetime includes ground test, ground storage periods, and in orbit storage and operations).

2.2.5 The study contractor shall analyze the effects of prolonged solar illumination into the optics and radiators when the instrument is in Off Mode or Safe Hold Mode.

2.2.6 The study contractor shall evaluate the ABI design, performance, risk, and implementation cost and schedule impacts (both non-recurring and recurring) of at least two defective detector element specifications, one with no defective elements, and the other with some amount of defective elements. The contractor shall define the measurement technique and decision criteria used to classify elements as defective, and the techniques and algorithms required to minimize the degradations in resampled image pixels due to defective elements (see PORD, section 3.2.5.6).

2.2.7 The contractor shall perform a reliability analysis to demonstrate that the preliminary ABI design can meet its required lifetime. As part of this analysis the contractor shall describe the fault tolerant/graceful degradation features of the design.

2.2.8 The contractor shall develop a draft verification plan that addresses verification at both the instrument level and the spacecraft I&T level. Plans for both the engineering model and flight models shall be addressed. Special emphasis should be given to the verification approach and GSE to be used for calibration, the resampling approach, and image navigation and registration.

2.2.9 The contractor shall specify the resampling algorithm to be used for ABI image data remapping to the fixed grid coordinate system (see ABI Performance and Operation Requirements, Section 1.2), the star sense algorithm, and the data compression and decompression algorithms. The expected performance of these algorithms and their rationale for selection shall be presented. In addition, the contractor shall estimate the processing load to implement the ground processing portion of these algorithms.

2.2.10 The contractor shall develop a computer simulation that models the output of ABI ground processing, including a demonstration of the image decompression and resampling algorithms, at the full data rate of the ABI. The simulation shall be used to demonstrate and quantify the impact of processing on ABI image quality, and shall include models of ABI scanning artifacts, the instrument to spacecraft transfer function, and estimated spacecraft orbit and attitude errors (spacecraft performance estimates will be provided by the government no later than the first

status meeting). Standard earth scenes will be made available by the government for this activity after contract award. Performance parameters to be evaluated include, but are not limited to, the following (listed along with associated ABI Performance and Operation Requirements paragraph numbers): 3.2.3 spatial resolution and sampling (MTF), 3.2.4.5 channel-to-channel registration after resampling, 3.2.5.2 relative precision, 3.2.5.3 coherent noise, and 3.2.5.4 on-orbit Vis/Nir calibration (i.e. application of calibration acquired on orbit).

2.3 Tool Development

2.3.1 The contractor shall develop a requirements traceability tool or utilize an existing tool (flowing down to the subsystem or lower level) and demonstrate that the ABI preliminary design meets all requirements.

2.3.2 The contractor shall develop simulations and analytical tools, including a radiometric mathematical model, in support of the preliminary design and trade study effort. These tools shall be useable throughout the ABI Implementation Phase. It is the intention of the government to make these tools deliverable items early in the implementation phase by the selected ABI vendor, and to have these tools supported and updated by the ABI vendor throughout the implementation phase.

2.4 Technology Assessment and Demonstration

2.4.1 The contractor shall finalize the assessment of technology readiness for ABI implementation, and refine a detailed plan to validate through breadboards, prototypes, lifetime testing, and similar validation techniques all technologies not deemed to be ready for implementation. The technology readiness criterion is that all technologies shall attain Technology Readiness Level (TRL) 6 (i.e., system or sub-system prototype demonstrated in a relevant environment) or higher by the end of the study period.

2.4.2 The contractor shall demonstrate through breadboards, prototypes, and similar validation techniques all required technologies that do not meet the readiness criterion.

2.5 Management Planning

2.5.1 The contractor shall develop a draft management plan for the Implementation Phase of ABI development.

2.5.2 The contractor shall identify risks to the development of the ABI, assess these risks using appropriate metrics, and develop risk reduction techniques to mitigate them. A draft risk management plan shall be developed. Alternate implementation paths should be identified for all high-risk items. The plan should be instituted as appropriate during the formulation phase.

2.5.3 The contractor shall develop implementation phase schedule estimates for the baseline ABI design. The contractor shall recommend a parts procurement strategy

that addresses procurement of long-lead items and their impact on the implementation schedule

2.5.4 The contractor shall define the cost estimation techniques that will be used during formulation phase activities. The contractor shall perform time-phased cost analyses for development and production of four flight model ABI and one engineering model ABI. Costs shall be separately identified for required GSE, spacecraft-level integration and test, and expected launch and on-orbit checkout support. Appropriate cost analyses shall also be performed to support all other trade studies and analyses required during the study period.

3. Reviews and Reporting

The contractor shall perform the reviews and reporting tasks as specified below.

3.1 Progress Reviews

Six (6) Progress Reviews shall be held prior to the Formulation Phase Design and Cost Review. The Midterm Review shall take the place of a Progress Review at that time. These reviews, which are estimated to last from 1/2 to one full day, are used to present the results of the work performed since the previous review and to discuss relevant technical and programmatic issues and findings. Some of these reviews may be held as videoconferences or teleconferences, but face-to-face meetings alternating between government and contractor sites is preferred. The presentation material is the deliverable.

3.2 Midterm Report

This report shall concentrate on the results of the ABI trade studies, general analyses, and the ABI requirements and their design implications (Section 2.1). Suggested ABI Requirements changes shall be presented. The initial ABI concepts used as the basis for trade studies shall be presented. This report shall consist of the Midterm Review viewgraph package with comprehensive facing page text. Additional material that is not presented at the Midterm Review may be appended if the study contractor so desires.

3.3 Midterm Review (System Requirements Review, SRR) - to be held at the NASA Goddard Space Flight Center.

This review shall concentrate on the results of the ABI trade studies and general analyses and on the ABI requirements and their design implications (Section 2.1). Suggested ABI requirements changes shall be presented at the Midterm Review. The initial ABI concepts used as the basis for trade studies shall be presented. The review package shall be the same document that is submitted for the Midterm Report as stated in Section 3.2.

3.4 Formulation Phase Design and Cost Review (FPDCR) - to be held at the contractor's facility.

The FPDCR shall summarize the results of the work performed under the contract including the analyses and trade studies performed, the ABI preliminary design,

and plans for the Implementation Phase. All topics listed in Section 3.5 shall be addressed.

3.5 Final Report

The Final Report shall document all work performed under the formulation phase contract. It shall describe in detail the trade studies and analyses performed, the preliminary design, and the plans for the Implementation Phase. The Final Report shall include, but not limited to, the following:

- Results of the trade studies and general analyses
- Requirements assessment and recommended changes
- Preliminary ABI design and related analyses, including, but not limited to:
  - Draft instrument performance specification
  - Preliminary subsystem designs, analyses, and performance budgets and margins
  - Compliance with the requirements
  - Draft instrument-to-spacecraft interfaces
  - Draft subsystem-level specifications and interfaces
  - Pre- and post-launch calibration
  - Preliminary design analysis results
  - Modular features and upgradability
  - Draft software design and specifications
  - Detector temperature and defective pixel analyses
  - Reliability analyses
  - Draft verification plan
  - Image data resampling algorithm, star sense algorithm, and data compression/decompression algorithms
  - ABI image data simulation analysis and results
  - Additional design elements as proposed by the study contractor
- Requirements traceability tool
- Simulations and analytical tools
- Technology readiness and availability assessment
- Technology demonstrations and results
- Draft ABI management plan
- Risk assessment and draft risk management plan
- Schedule estimates and long lead item procurement plan
- Documented cost estimates for the baseline ABI design and for design trades